Sonoma Technology, Inc.
*Environmental Science and Innovative Solutions*

# Technical Memorandum

October 10, 2017 STI-917011

To: Tony Mendoza, Sierra Club

From: Kenneth J. Craig and Lyle R. Chinkin

**Re: Ozone Impacts in 2011 from White Bluff and Independence Power Plants in Arkansas**

## Executive Summary

Sonoma Technology, Inc. (STI) performed source apportionment modeling to analyze impacts of emissions from the Arkansas White Bluff and Independence power plants in 2011 on air quality in the St. Louis ozone nonattainment area. The results of this analysis showed that emissions from White Bluff and Independence individually and collectively contribute significantly to ozone concentrations in the St. Louis ozone nonattainment area during the modeled ozone season. Modeled 8-hr ozone impacts in St. Louis were as large as 1.18 ppb from White Bluff and 2.73 ppb from Independence. Combined ozone impacts from White Bluff and Independence were as large as 3.63 ppb. In addition, impacts considered significant (>1% of the 2008 ozone National Ambient Air Quality Standards [NAAQS]) were modeled on as many as 5 days at a single St. Louis monitor due to emissions from White Bluff, as many as 8 days at a single St. Louis monitor due to emissions from Independence, and as many as 22 days (14% of modeled days) at a single St. Louis monitor due to combined emissions from White Bluff and Independence. When considering ozone impacts across all St. Louis nonattainment monitors, significant (>0.75 ppb) ozone impacts were modeled on 19 monitor-days due to emissions from White Bluff, 60 monitor-days due to emissions from Independence, and 156 monitor-days due to combined emissions from White Bluff and Independence

## Introduction

STI performed source apportionment modeling using the Comprehensive Air Quality Model with Extensions (CAMx) with Ozone Source Apportionment Technology (OSAT) to evaluate ozone impacts from coal-fired power plants and other emission sources on downwind receptors in nonattainment areas. The source apportionment modeling was conducted for the 2011 ozone season (May to September) for a domain covering the continental United States at 12-km spatial resolution (Figure 1), and results were compiled into a series of databases that can be used for future data mining and analysis. Additional details on the models, data, and methods used can be found in Appendix A.

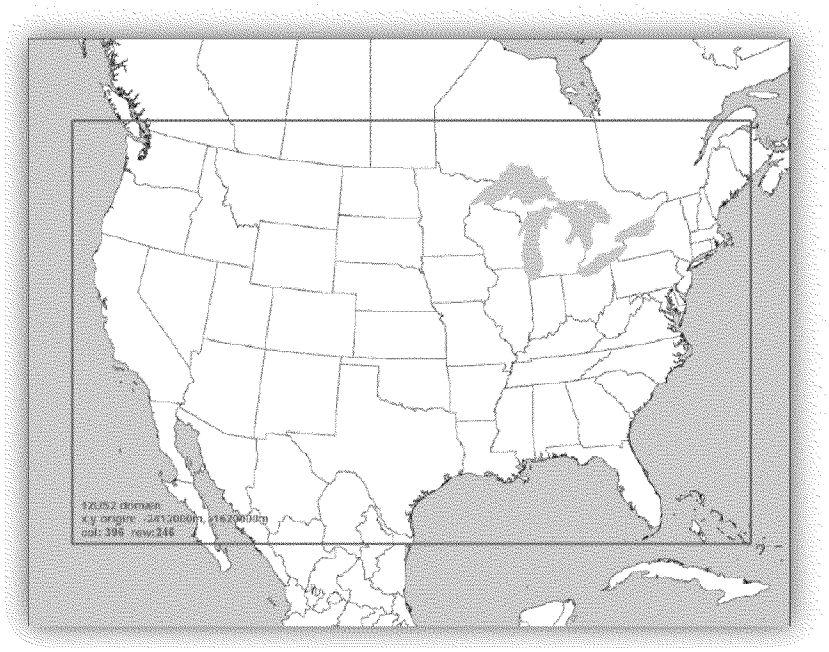

Figure 1. Modeling domain for the source apportionment model simulations. Source: U.S. Environmental Protection Agency (2015).

STI used the results from this source apportionment modeling to analyze impacts of emissions from the White Bluff and Independence power plants in Arkansas on air quality monitor locations in the St. Louis ozone nonattainment area. The 11 monitors considered in this analysis are shown in Table 1. For this analysis, modeled 8-hr ozone impacts greater than 1% of the NAAQS are considered significant. For the 2008 ozone NAAQS, this significance threshold is 0.75 ppb. This type of significance threshold is consistent with how the U.S. Environmental Protection Agency (EPA) has previously defined significant interstate contributions for ozone and $PM_{2.5}$.[1]

[1] See 75 Federal Register (August 2, 2010) and 76 Federal Register (August 8, 2011), 40 CFR Parts 51, 52, 72, 78, and 97.

Table 1. Ozone monitoring stations in the St. Louis ozone nonattainment area.

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State |
|---|---|---|---|
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois |
| 171193007 | WATER PLANT | Madison | Illinois |
| 171199991 | Alhambra | Madison | Illinois |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois |
| 290990019 | Arnold West | Jefferson | Missouri |
| 291831002 | West Alton | Saint Charles | Missouri |
| 291831004 | Orchard Farm | Saint Charles | Missouri |
| 291890005 | Pacific | Saint Louis | Missouri |
| 291890014 | Maryland Heights | Saint Louis | Missouri |
| 295100085 | Blair Street | St. Louis City | Missouri |

In summary, the modeling results showed that emissions from White Bluff and Independence independently and collectively contribute significantly to ozone formation downwind in St. Louis during the 2011 ozone season. Modeled 8-hr ozone impacts in St. Louis were as large as 1.18 ppb from White Bluff and 2.73 ppb from Independence. Combined ozone impacts from White Bluff and Independence were as large as 3.63 ppb. In addition, significant impacts (>0.75 ppb) were modeled on as many as 5 days at a single St. Louis monitor due to emissions from White Bluff, as many as 8 days at a single St. Louis monitor due to emissions from Independence, and as many as 22 days (14% of modeled days) at a single St. Louis monitor due to combined emissions from White Bluff and Independence. A summary of significant (>0.75 ppb) modeled ozone impacts on St. Louis monitors is shown in Table 2.

**Table 2.** Summary of significant (>0.75 ppb) modeled 8-hr ozone impacts on St. Louis nonattainment monitors. A "monitor-day" refers to one occurrence of a significant ozone contribution at one monitor on one day.

| Power Plant | Maximum Number of Significant Impact Days at a St. Louis Monitor | Monitor-Days with Significant Ozone Contributions | Peak Ozone Contribution (ppb) |
|---|---|---|---|
| White Bluff | 5 | 19 | 1.18 |
| Independence | 8 | 60 | 2.73 |
| White Bluff and Independence Combined | 22 | 156 | 3.63 |

## White Bluff Ozone Contributions in St. Louis

White Bluff is a coal-fired electrical generating facility in Jefferson County, Arkansas. The plant is about 25 miles south of Little Rock, AR, and approximately 300 miles south-southwest of St. Louis. The plant has two major boiler units, built in the early 1980s, with approximately 1,500+ Megawatts of capacity.[2] In 2011, the total $NO_x$ emissions from White Bluff were 16,013 tons, making White Bluff among the highest $NO_x$ emitters of all tagged power plants in the source apportionment modeling.

Table 3 shows the highest significant (>0.75 ppb) modeled ozone contributions at St. Louis monitors due to White Bluff emissions during the 2011 ozone season, as well as the number of days with significant modeled ozone impacts. The largest overall modeled ozone impact was 1.18 ppb at the Pacific monitor in St. Louis County, Missouri, and the Arnold West monitor in Jefferson County, Missouri. Significant impacts occurred on as many as 5 days at a single St. Louis monitor. A full listing of days when modeled ozone contributions from White Bluff exceeded 0.75 ppb at St. Louis monitors is shown Table 4.

Table 3. Peak modeled 8-hr average ozone impacts and number of days with significant (>0.75 ppb) modeled 8-hr average ozone impacts at St. Louis nonattainment monitors due to White Bluff emissions during the 2011 ozone season, ranked by peak modeled impact. Only monitors with a significant modeled impact are shown

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | White Bluff Maximum Modeled Contribution (ppb) | Number of Significant Impact Days |
|---|---|---|---|---|---|
| 291890005 | Pacific | Saint Louis | Missouri | 1.18 | 5 |
| 290990019 | Arnold West | Jefferson | Missouri | 1.18 | 3 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 1.03 | 2 |
| 295100085 | Blair Street | St. Louis City | Missouri | 0.95 | 1 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 0.93 | 3 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 0.93 | 1 |
| 291831002 | West Alton | Saint Charles | Missouri | 0.85 | 1 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 0.82 | 1 |
| 171193007 | WATER PLANT | Madison | Illinois | 0.82 | 1 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 0.80 | 1 |

[2] http://www.sourcewatch.org/index.php/White_Bluff_Generating_Plant

**Table 4.** Summary of significant (>0.75 ppb) modeled 8-hr average ozone impacts at St. Louis nonattainment monitors due to White Bluff emissions during the 2011 ozone season. Significant impacts were modeled at one or more monitors on 5 days.

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | White Bluff Modeled Contribution (ppb) |
|---|---|---|---|---|---|---|---|
| 291831004 | Orchard Farm | Saint Charles | Missouri | 6 | 7 | 2011 | 0.86 |
| 291890005 | Pacific | Saint Louis | Missouri | 6 | 7 | 2011 | 0.93 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 6 | 7 | 2011 | 0.83 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 7 | 23 | 2011 | 0.82 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 23 | 2011 | 0.80 |
| 171193007 | WATER PLANT | Madison | Illinois | 7 | 23 | 2011 | 0.82 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 7 | 23 | 2011 | 0.93 |
| 290990019 | Arnold West | Jefferson | Missouri | 7 | 23 | 2011 | 1.18 |
| 291831002 | West Alton | Saint Charles | Missouri | 7 | 23 | 2011 | 0.85 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 7 | 23 | 2011 | 0.90 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 23 | 2011 | 1.18 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 7 | 23 | 2011 | 1.03 |
| 295100085 | Blair Street | St. Louis City | Missouri | 7 | 23 | 2011 | 0.95 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 7 | 27 | 2011 | 0.93 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 27 | 2011 | 0.91 |
| 290990019 | Arnold West | Jefferson | Missouri | 8 | 31 | 2011 | 0.78 |
| 291890005 | Pacific | Saint Louis | Missouri | 8 | 31 | 2011 | 0.82 |
| 290990019 | Arnold West | Jefferson | Missouri | 9 | 2 | 2011 | 0.80 |
| 291890005 | Pacific | Saint Louis | Missouri | 9 | 2 | 2011 | 0.78 |

## Independence Ozone Contributions in St. Louis

Independence is a coal-fired electrical generating facility in Independence County, Arkansas. The plant is about 80 miles northeast of Little Rock, AR, and approximately 210 miles south-southwest of St. Louis. The plant has two major boiler units, built in the mid-1980s, with approximately 1,500+ Megawatts of capacity.[3] In 2011, the total $NO_x$ emissions from Independence were 13,411 tons

Table 5 shows the highest significant (>0.75 ppb) modeled ozone contributions at St. Louis monitors due to Independence emissions during the 2011 ozone season, as well as the number of days with significant modeled ozone impacts. The largest overall modeled ozone impact was 2.73 ppb at the Pacific monitor in St. Louis County, Missouri The highest modeled impacts were significant (>0.75 ppb) at all 11 St. Louis monitors, and greater than 2 ppb at three of the St. Louis monitors. Significant impacts occurred on as many as 8 days at a single St. Louis monitor. A full listing of days when modeled ozone contributions from Independence exceeded 0.75 ppb at St. Louis monitors is shown Table 6.

Table 5. Peak modeled 8-hr average ozone impacts and number of days with significant (>0.75 ppb) modeled 8-hr average ozone impacts at St. Louis nonattainment monitors due to Independence emissions during the 2011 ozone season, ranked by peak modeled impact.

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Independence Maximum Modeled Contribution (ppb) | Number of Significant Impact Days |
|---|---|---|---|---|---|
| 291890005 | Pacific | Saint Louis | Missouri | 2.73 | 8 |
| 290990019 | Arnold West | Jefferson | Missouri | 2.02 | 8 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 2.01 | 5 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 1.99 | 4 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 1.71 | 5 |
| 295100085 | Blair Street | St. Louis City | Missouri | 1.60 | 5 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 1.57 | 7 |
| 291831002 | West Alton | Saint Charles | Missouri | 1.52 | 5 |
| 171199991 | Alhambra | Madison | Illinois | 1.45 | 5 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 1.42 | 4 |
| 171193007 | WATER PLANT | Madison | Illinois | 1.42 | 4 |

[3] http://www.sourcewatch.org/index.php/Independence_Steam_Station

**Table 6.** Summary of significant (>0.75 ppb) modeled 8-hr average ozone impacts at St. Louis monitors due to Independence emissions during the 2011 ozone season. Significant impacts were modeled at one or more monitors on 12 days.

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | Independence Modeled Contribution (ppb) |
|---|---|---|---|---|---|---|---|
| 290990019 | Arnold West | Jefferson | Missouri | 5 | 9 | 2011 | 0.77 |
| 291890005 | Pacific | Saint Louis | Missouri | 5 | 9 | 2011 | 0.94 |
| 291890005 | Pacific | Saint Louis | Missouri | 6 | 2 | 2011 | 0.98 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 6 | 3 | 2011 | 0.82 |
| 171199991 | Alhambra | Madison | Illinois | 6 | 3 | 2011 | 0.87 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 6 | 3 | 2011 | 0.87 |
| 290990019 | Arnold West | Jefferson | Missouri | 6 | 3 | 2011 | 0.88 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 6 | 7 | 2011 | 1.42 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 6 | 7 | 2011 | 1.57 |
| 171193007 | WATER PLANT | Madison | Illinois | 6 | 7 | 2011 | 1.42 |
| 171199991 | Alhambra | Madison | Illinois | 6 | 7 | 2011 | 1.42 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 6 | 7 | 2011 | 1.71 |
| 290990019 | Arnold West | Jefferson | Missouri | 6 | 7 | 2011 | 2.02 |
| 291831002 | West Alton | Saint Charles | Missouri | 6 | 7 | 2011 | 1.28 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 6 | 7 | 2011 | 1.09 |
| 291890005 | Pacific | Saint Louis | Missouri | 6 | 7 | 2011 | 1.77 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 6 | 7 | 2011 | 1.49 |
| 295100085 | Blair Street | St. Louis City | Missouri | 6 | 7 | 2011 | 1.60 |
| 290990019 | Arnold West | Jefferson | Missouri | 6 | 27 | 2011 | 0.95 |
| 291890005 | Pacific | Saint Louis | Missouri | 6 | 27 | 2011 | 0.77 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 1 | 2011 | 1.02 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 7 | 1 | 2011 | 0.80 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 7 | 19 | 2011 | 0.78 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 19 | 2011 | 0.88 |
| 171193007 | WATER PLANT | Madison | Illinois | 7 | 19 | 2011 | 0.78 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 7 | 19 | 2011 | 0.99 |
| 290990019 | Arnold West | Jefferson | Missouri | 7 | 19 | 2011 | 1.16 |
| 291831002 | West Alton | Saint Charles | Missouri | 7 | 19 | 2011 | 0.78 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 7 | 19 | 2011 | 0.81 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 19 | 2011 | 1.03 |

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | Independence Modeled Contribution (ppb) |
|---|---|---|---|---|---|---|---|
| 291890014 | Maryland Heights | Saint Louis | Missouri | 7 | 19 | 2011 | 0.95 |
| 295100085 | Blair Street | St. Louis City | Missouri | 7 | 19 | 2011 | 0.94 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 7 | 23 | 2011 | 1.04 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 23 | 2011 | 1.30 |
| 171193007 | WATER PLANT | Madison | Illinois | 7 | 23 | 2011 | 1.04 |
| 171199991 | Alhambra | Madison | Illinois | 7 | 23 | 2011 | 1.45 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 7 | 23 | 2011 | 1.23 |
| 290990019 | Arnold West | Jefferson | Missouri | 7 | 23 | 2011 | 0.93 |
| 291831002 | West Alton | Saint Charles | Missouri | 7 | 23 | 2011 | 0.75 |
| 295100085 | Blair Street | St. Louis City | Missouri | 7 | 23 | 2011 | 0.90 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 7 | 27 | 2011 | 1.17 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 27 | 2011 | 0.79 |
| 171193007 | WATER PLANT | Madison | Illinois | 7 | 27 | 2011 | 1.17 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 7 | 27 | 2011 | 1.18 |
| 290990019 | Arnold West | Jefferson | Missouri | 7 | 27 | 2011 | 1.80 |
| 291831002 | West Alton | Saint Charles | Missouri | 7 | 27 | 2011 | 1.52 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 7 | 27 | 2011 | 1.99 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 27 | 2011 | 2.73 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 7 | 27 | 2011 | 2.01 |
| 295100085 | Blair Street | St. Louis City | Missouri | 7 | 27 | 2011 | 1.59 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 28 | 2011 | 0.76 |
| 171199991 | Alhambra | Madison | Illinois | 7 | 28 | 2011 | 0.94 |
| 290990019 | Arnold West | Jefferson | Missouri | 8 | 2 | 2011 | 0.83 |
| 291831002 | West Alton | Saint Charles | Missouri | 8 | 2 | 2011 | 0.81 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 8 | 2 | 2011 | 0.83 |
| 291890005 | Pacific | Saint Louis | Missouri | 8 | 2 | 2011 | 1.02 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 8 | 2 | 2011 | 0.82 |
| 295100085 | Blair Street | St. Louis City | Missouri | 8 | 2 | 2011 | 0.78 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 8 | 31 | 2011 | 0.86 |
| 171199991 | Alhambra | Madison | Illinois | 8 | 31 | 2011 | 0.89 |

## Combined White Bluff and Independence Ozone Contributions in St. Louis

In 2011, the total combined $NO_x$ emissions from the White Bluff and Independence power plants were 29,424 tons. Emissions from White Bluff and Independence individually and collectively contributed significantly to ozone concentrations in the St. Louis ozone nonattainment area during the modeled ozone season. Table 7 shows the highest significant (>0.75 ppb) modeled ozone contributions at St. Louis monitors due to the combination of White Bluff and Independence emissions during the 2011 ozone season, as well as the number of days with significant modeled ozone impacts. The largest overall combined impact was 3.63 ppb. The highest combined modeled impacts were significant (>0.75 ppb) at all 11 St. Louis monitors, and greater than 2 ppb at 9 of the 11 St. Louis monitors. Significant impacts occurred on as many as 22 days (14% of modeled days) at a single St. Louis monitor, and 27 days at one or more St. Louis monitors. When considering ozone impacts across all St. Louis nonattainment monitors, significant (> 0.75 ppb) ozone impacts were modeled on 19 monitor-days[4] due to emissions from White Bluff, 60 monitor-days due to emissions from Independence, and 156 monitor-days due to combined emissions from White Bluff and Independence (Table 2). A full listing of days when modeled ozone impacts due combined emissions from White Bluff and Independence exceeded 0.75 ppb at St. Louis monitors is shown Table 8.

[4] A monitor-day refers to one occurrence of a significant ozone contribution at one monitor on one day.

**Table 7.** Peak modeled 8-hr average ozone impacts and number of days with significant (>0.75 ppb) modeled 8-hr average ozone impacts at St. Louis nonattainment monitors due to the combination of White Bluff and Independence emissions during the 2011 ozone season, ranked by peak modeled impact.

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | White Bluff and Independence Combined Maximum Modeled Contribution (ppb) | Number of Significant Impact Days |
|---|---|---|---|---|---|
| 291890005 | Pacific | Saint Louis | Missouri | 3.63 | 22 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 2.93 | 12 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 2.74 | 17 |
| 290990019 | Arnold West | Jefferson | Missouri | 2.55 | 18 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 2.16 | 16 |
| 171199991 | Alhambra | Madison | Illinois | 2.14 | 11 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 2.10 | 13 |
| 295100085 | Blair Street | St. Louis City | Missouri | 2.06 | 13 |
| 291831002 | West Alton | Saint Charles | Missouri | 2.00 | 10 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 1.87 | 12 |
| 171193007 | WATER PLANT | Madison | Illinois | 1.87 | 12 |

Table 8. Summary of significant (>0.75 ppb) modeled 8-hr average ozone impacts at St. Louis monitors due to the combination of White Bluff and Independence emissions during the 2011 ozone season. Significant impacts were modeled at one or more monitors on 27 days.

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | White Bluff Modeled Contribution (ppb) | Independence Modeled Contribution (ppb) | Sum of White Bluff and Independence Modeled Contributions (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 291890005 | Pacific | Saint Louis | Missouri | 5 | 5 | 2011 | 0.49 | 0.27 | 0.77 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 5 | 9 | 2011 | 0.51 | 0.41 | 0.91 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 5 | 9 | 2011 | 0.53 | 0.37 | 0.90 |
| 171193007 | WATER PLANT | Madison | Illinois | 5 | 9 | 2011 | 0.51 | 0.41 | 0.91 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 5 | 9 | 2011 | 0.64 | 0.52 | 1.17 |
| 290990019 | Arnold West | Jefferson | Missouri | 5 | 9 | 2011 | 0.66 | 0.77 | 1.43 |
| 291831002 | West Alton | Saint Charles | Missouri | 5 | 9 | 2011 | 0.52 | 0.48 | 0.99 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 5 | 9 | 2011 | 0.45 | 0.56 | 1.01 |
| 291890005 | Pacific | Saint Louis | Missouri | 5 | 9 | 2011 | 0.54 | 0.94 | 1.48 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 5 | 9 | 2011 | 0.58 | 0.73 | 1.31 |
| 295100085 | Blair Street | St. Louis City | Missouri | 5 | 9 | 2011 | 0.55 | 0.54 | 1.09 |
| 290990019 | Arnold West | Jefferson | Missouri | 5 | 24 | 2011 | 0.26 | 0.60 | 0.87 |
| 291890005 | Pacific | Saint Louis | Missouri | 5 | 24 | 2011 | 0.29 | 0.57 | 0.86 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 5 | 29 | 2011 | 0.30 | 0.45 | 0.75 |
| 290990019 | Arnold West | Jefferson | Missouri | 5 | 29 | 2011 | 0.31 | 0.52 | 0.82 |
| 291890005 | Pacific | Saint Louis | Missouri | 5 | 29 | 2011 | 0.26 | 0.51 | 0.77 |
| 290990019 | Arnold West | Jefferson | Missouri | 5 | 30 | 2011 | 0.38 | 0.41 | 0.80 |

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | White Bluff Modeled Contribution (ppb) | Independence Modeled Contribution (ppb) | Sum of White Bluff and Independence Modeled Contributions (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 291890005 | Pacific | Saint Louis | Missouri | 5 | 30 | 2011 | 0.46 | 0.48 | 0.95 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 5 | 30 | 2011 | 0.40 | 0.42 | 0.82 |
| 291890005 | Pacific | Saint Louis | Missouri | 6 | 2 | 2011 | 0.25 | 0.98 | 1.23 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 6 | 2 | 2011 | 0.17 | 0.68 | 0.85 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 6 | 3 | 2011 | 0.51 | 0.72 | 1.23 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 6 | 3 | 2011 | 0.47 | 0.82 | 1.28 |
| 171193007 | WATER PLANT | Madison | Illinois | 6 | 3 | 2011 | 0.51 | 0.72 | 1.23 |
| 171199991 | Alhambra | Madison | Illinois | 6 | 3 | 2011 | 0.48 | 0.87 | 1.35 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 6 | 3 | 2011 | 0.51 | 0.87 | 1.38 |
| 290990019 | Arnold West | Jefferson | Missouri | 6 | 3 | 2011 | 0.59 | 0.88 | 1.47 |
| 291831002 | West Alton | Saint Charles | Missouri | 6 | 3 | 2011 | 0.50 | 0.58 | 1.08 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 6 | 3 | 2011 | 0.52 | 0.49 | 1.01 |
| 291890005 | Pacific | Saint Louis | Missouri | 6 | 3 | 2011 | 0.57 | 0.63 | 1.20 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 6 | 3 | 2011 | 0.55 | 0.60 | 1.16 |
| 295100085 | Blair Street | St. Louis City | Missouri | 6 | 3 | 2011 | 0.52 | 0.74 | 1.26 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 6 | 7 | 2011 | 0.43 | 1.42 | 1.85 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 6 | 7 | 2011 | 0.24 | 1.57 | 1.80 |
| 171193007 | WATER PLANT | Madison | Illinois | 6 | 7 | 2011 | 0.43 | 1.42 | 1.85 |
| 171199991 | Alhambra | Madison | Illinois | 6 | 7 | 2011 | 0.13 | 1.42 | 1.55 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 6 | 7 | 2011 | 0.32 | 1.71 | 2.04 |
| 290990019 | Arnold West | Jefferson | Missouri | 6 | 7 | 2011 | 0.53 | 2.02 | 2.55 |
| 291831002 | West Alton | Saint Charles | Missouri | 6 | 7 | 2011 | 0.54 | 1.28 | 1.83 |

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | White Bluff Modeled Contribution (ppb) | Independence Modeled Contribution (ppb) | Sum of White Bluff and Independence Modeled Contributions (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 291831004 | Orchard Farm | Saint Charles | Missouri | 6 | 7 | 2011 | 0.86 | 1.09 | 1.95 |
| 291890005 | Pacific | Saint Louis | Missouri | 6 | 7 | 2011 | 0.93 | 1.77 | 2.70 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 6 | 7 | 2011 | 0.83 | 1.49 | 2.32 |
| 295100085 | Blair Street | St. Louis City | Missouri | 6 | 7 | 2011 | 0.46 | 1.60 | 2.06 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 6 | 17 | 2011 | 0.39 | 0.38 | 0.77 |
| 290990019 | Arnold West | Jefferson | Missouri | 6 | 17 | 2011 | 0.61 | 0.59 | 1.20 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 6 | 17 | 2011 | 0.50 | 0.39 | 0.89 |
| 291890005 | Pacific | Saint Louis | Missouri | 6 | 17 | 2011 | 0.73 | 0.67 | 1.40 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 6 | 17 | 2011 | 0.58 | 0.53 | 1.11 |
| 295100085 | Blair Street | St. Louis City | Missouri | 6 | 17 | 2011 | 0.39 | 0.37 | 0.76 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 6 | 21 | 2011 | 0.40 | 0.37 | 0.77 |
| 171193007 | WATER PLANT | Madison | Illinois | 6 | 21 | 2011 | 0.40 | 0.37 | 0.77 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 6 | 21 | 2011 | 0.46 | 0.40 | 0.86 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 6 | 27 | 2011 | 0.34 | 0.62 | 0.96 |
| 171199991 | Alhambra | Madison | Illinois | 6 | 27 | 2011 | 0.31 | 0.56 | 0.87 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 6 | 27 | 2011 | 0.38 | 0.72 | 1.10 |
| 290990019 | Arnold West | Jefferson | Missouri | 6 | 27 | 2011 | 0.51 | 0.95 | 1.46 |
| 291890005 | Pacific | Saint Louis | Missouri | 6 | 27 | 2011 | 0.48 | 0.77 | 1.25 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 6 | 27 | 2011 | 0.37 | 0.62 | 0.99 |
| 295100085 | Blair Street | St. Louis City | Missouri | 6 | 27 | 2011 | 0.33 | 0.61 | 0.93 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 7 | 1 | 2011 | 0.14 | 0.69 | 0.83 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 1 | 2011 | 0.17 | 1.02 | 1.18 |

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | White Bluff Modeled Contribution (ppb) | Independence Modeled Contribution (ppb) | Sum of White Bluff and Independence Modeled Contributions (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 291890014 | Maryland Heights | Saint Louis | Missouri | 7 | 1 | 2011 | 0.14 | 0.80 | 0.94 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 7 | 2 | 2011 | 0.25 | 0.54 | 0.79 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 2 | 2011 | 0.24 | 0.58 | 0.82 |
| 171193007 | WATER PLANT | Madison | Illinois | 7 | 2 | 2011 | 0.25 | 0.54 | 0.79 |
| 171199991 | Alhambra | Madison | Illinois | 7 | 2 | 2011 | 0.19 | 0.65 | 0.84 |
| 290990019 | Arnold West | Jefferson | Missouri | 7 | 7 | 2011 | 0.21 | 0.64 | 0.85 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 7 | 2011 | 0.26 | 0.73 | 0.99 |
| 290990019 | Arnold West | Jefferson | Missouri | 7 | 10 | 2011 | 0.18 | 0.63 | 0.81 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 7 | 10 | 2011 | 0.20 | 0.55 | 0.76 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 10 | 2011 | 0.21 | 0.71 | 0.92 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 7 | 10 | 2011 | 0.20 | 0.61 | 0.82 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 7 | 19 | 2011 | 0.03 | 0.78 | 0.82 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 19 | 2011 | 0.03 | 0.88 | 0.91 |
| 171193007 | WATER PLANT | Madison | Illinois | 7 | 19 | 2011 | 0.03 | 0.78 | 0.82 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 7 | 19 | 2011 | 0.03 | 0.99 | 1.02 |
| 290990019 | Arnold West | Jefferson | Missouri | 7 | 19 | 2011 | 0.03 | 1.16 | 1.19 |
| 291831002 | West Alton | Saint Charles | Missouri | 7 | 19 | 2011 | 0.03 | 0.78 | 0.82 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 7 | 19 | 2011 | 0.04 | 0.81 | 0.85 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 19 | 2011 | 0.05 | 1.03 | 1.08 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 7 | 19 | 2011 | 0.04 | 0.95 | 0.99 |
| 295100085 | Blair Street | St. Louis City | Missouri | 7 | 19 | 2011 | 0.04 | 0.94 | 0.97 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 7 | 22 | 2011 | 0.45 | 0.33 | 0.78 |

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | White Bluff Modeled Contribution (ppb) | Independence Modeled Contribution (ppb) | Sum of White Bluff and Independence Modeled Contributions (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 22 | 2011 | 0.58 | 0.46 | 1.04 |
| 171193007 | WATER PLANT | Madison | Illinois | 7 | 22 | 2011 | 0.45 | 0.33 | 0.78 |
| 171199991 | Alhambra | Madison | Illinois | 7 | 22 | 2011 | 0.69 | 0.66 | 1.35 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 7 | 22 | 2011 | 0.52 | 0.38 | 0.90 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 7 | 23 | 2011 | 0.82 | 1.04 | 1.87 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 23 | 2011 | 0.80 | 1.30 | 2.10 |
| 171193007 | WATER PLANT | Madison | Illinois | 7 | 23 | 2011 | 0.82 | 1.04 | 1.87 |
| 171199991 | Alhambra | Madison | Illinois | 7 | 23 | 2011 | 0.69 | 1.45 | 2.14 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 7 | 23 | 2011 | 0.93 | 1.23 | 2.16 |
| 290990019 | Arnold West | Jefferson | Missouri | 7 | 23 | 2011 | 1.18 | 0.93 | 2.11 |
| 291831002 | West Alton | Saint Charles | Missouri | 7 | 23 | 2011 | 0.85 | 0.75 | 1.60 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 7 | 23 | 2011 | 0.90 | 0.42 | 1.32 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 23 | 2011 | 1.18 | 0.43 | 1.62 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 7 | 23 | 2011 | 1.03 | 0.50 | 1.53 |
| 295100085 | Blair Street | St. Louis City | Missouri | 7 | 23 | 2011 | 0.95 | 0.90 | 1.85 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 7 | 27 | 2011 | 0.25 | 1.17 | 1.41 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 27 | 2011 | 0.11 | 0.79 | 0.90 |
| 171193007 | WATER PLANT | Madison | Illinois | 7 | 27 | 2011 | 0.25 | 1.17 | 1.41 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 7 | 27 | 2011 | 0.21 | 1.18 | 1.39 |
| 290990019 | Arnold West | Jefferson | Missouri | 7 | 27 | 2011 | 0.40 | 1.80 | 2.20 |
| 291831002 | West Alton | Saint Charles | Missouri | 7 | 27 | 2011 | 0.48 | 1.52 | 2.00 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 7 | 27 | 2011 | 0.93 | 1.99 | 2.93 |

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | White Bluff Modeled Contribution (ppb) | Independence Modeled Contribution (ppb) | Sum of White Bluff and Independence Modeled Contributions (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 27 | 2011 | 0.91 | 2.73 | 3.63 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 7 | 27 | 2011 | 0.73 | 2.01 | 2.74 |
| 295100085 | Blair Street | St. Louis City | Missouri | 7 | 27 | 2011 | 0.39 | 1.59 | 1.98 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 7 | 28 | 2011 | 0.59 | 0.50 | 1.09 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 7 | 28 | 2011 | 0.49 | 0.76 | 1.25 |
| 171193007 | WATER PLANT | Madison | Illinois | 7 | 28 | 2011 | 0.59 | 0.50 | 1.09 |
| 171199991 | Alhambra | Madison | Illinois | 7 | 28 | 2011 | 0.38 | 0.94 | 1.31 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 7 | 28 | 2011 | 0.57 | 0.67 | 1.23 |
| 290990019 | Arnold West | Jefferson | Missouri | 7 | 28 | 2011 | 0.67 | 0.45 | 1.11 |
| 291831002 | West Alton | Saint Charles | Missouri | 7 | 28 | 2011 | 0.60 | 0.32 | 0.92 |
| 291890005 | Pacific | Saint Louis | Missouri | 7 | 28 | 2011 | 0.67 | 0.21 | 0.88 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 7 | 28 | 2011 | 0.61 | 0.24 | 0.84 |
| 295100085 | Blair Street | St. Louis City | Missouri | 7 | 28 | 2011 | 0.60 | 0.46 | 1.06 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 8 | 2 | 2011 | 0.17 | 0.66 | 0.83 |
| 171193007 | WATER PLANT | Madison | Illinois | 8 | 2 | 2011 | 0.17 | 0.66 | 0.83 |
| 290990019 | Arnold West | Jefferson | Missouri | 8 | 2 | 2011 | 0.20 | 0.83 | 1.03 |
| 291831002 | West Alton | Saint Charles | Missouri | 8 | 2 | 2011 | 0.27 | 0.81 | 1.08 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 8 | 2 | 2011 | 0.37 | 0.83 | 1.21 |
| 291890005 | Pacific | Saint Louis | Missouri | 8 | 2 | 2011 | 0.35 | 1.02 | 1.37 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 8 | 2 | 2011 | 0.28 | 0.82 | 1.10 |
| 295100085 | Blair Street | St. Louis City | Missouri | 8 | 2 | 2011 | 0.20 | 0.78 | 0.98 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 8 | 19 | 2011 | 0.18 | 0.64 | 0.82 |

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | White Bluff Modeled Contribution (ppb) | Independence Modeled Contribution (ppb) | Sum of White Bluff and Independence Modeled Contributions (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 171199991 | Alhambra | Madison | Illinois | 8 | 19 | 2011 | 0.17 | 0.60 | 0.78 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 8 | 19 | 2011 | 0.20 | 0.70 | 0.90 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 8 | 20 | 2011 | 0.45 | 0.36 | 0.80 |
| 290990019 | Arnold West | Jefferson | Missouri | 8 | 20 | 2011 | 0.43 | 0.32 | 0.76 |
| 291831002 | West Alton | Saint Charles | Missouri | 8 | 20 | 2011 | 0.48 | 0.33 | 0.81 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 8 | 20 | 2011 | 0.58 | 0.35 | 0.93 |
| 291890005 | Pacific | Saint Louis | Missouri | 8 | 20 | 2011 | 0.61 | 0.34 | 0.96 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 8 | 20 | 2011 | 0.56 | 0.34 | 0.90 |
| 295100085 | Blair Street | St. Louis City | Missouri | 8 | 20 | 2011 | 0.44 | 0.32 | 0.76 |
| 171190008 | CLARA BARTON SCHOOL | Madison | Illinois | 8 | 31 | 2011 | 0.68 | 0.64 | 1.31 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 8 | 31 | 2011 | 0.69 | 0.86 | 1.56 |
| 171193007 | WATER PLANT | Madison | Illinois | 8 | 31 | 2011 | 0.68 | 0.64 | 1.31 |
| 171199991 | Alhambra | Madison | Illinois | 8 | 31 | 2011 | 0.55 | 0.89 | 1.44 |
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 8 | 31 | 2011 | 0.70 | 0.75 | 1.45 |
| 290990019 | Arnold West | Jefferson | Missouri | 8 | 31 | 2011 | 0.78 | 0.64 | 1.43 |
| 291831002 | West Alton | Saint Charles | Missouri | 8 | 31 | 2011 | 0.56 | 0.35 | 0.92 |
| 291890005 | Pacific | Saint Louis | Missouri | 8 | 31 | 2011 | 0.82 | 0.59 | 1.40 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 8 | 31 | 2011 | 0.64 | 0.30 | 0.94 |
| 295100085 | Blair Street | St. Louis City | Missouri | 8 | 31 | 2011 | 0.63 | 0.49 | 1.12 |
| 171199991 | Alhambra | Madison | Illinois | 9 | 1 | 2011 | 0.52 | 0.24 | 0.75 |
| 171191009 | SOUTHWEST CABLE TV | Madison | Illinois | 9 | 2 | 2011 | 0.65 | 0.24 | 0.89 |
| 171199991 | Alhambra | Madison | Illinois | 9 | 2 | 2011 | 0.64 | 0.34 | 0.99 |

| AQS Site ID | Monitor Local Site Name | Monitor County | Monitor State | Month | Day | Year | White Bluff Modeled Contribution (ppb) | Independence Modeled Contribution (ppb) | Sum of White Bluff and Independence Modeled Contributions (ppb) |
|---|---|---|---|---|---|---|---|---|---|
| 171630010 | IEPA-RAPS TRAILER | Saint Clair | Illinois | 9 | 2 | 2011 | 0.74 | 0.20 | 0.94 |
| 290990019 | Arnold West | Jefferson | Missouri | 9 | 2 | 2011 | 0.80 | 0.15 | 0.95 |
| 291890005 | Pacific | Saint Louis | Missouri | 9 | 2 | 2011 | 0.78 | 0.07 | 0.84 |
| 291890014 | Maryland Heights | Saint Louis | Missouri | 9 | 2 | 2011 | 0.73 | 0.07 | 0.79 |
| 295100085 | Blair Street | St. Louis City | Missouri | 9 | 2 | 2011 | 0.67 | 0.13 | 0.80 |
| 291831004 | Orchard Farm | Saint Charles | Missouri | 9 | 3 | 2011 | 0.16 | 0.60 | 0.76 |
| 291890005 | Pacific | Saint Louis | Missouri | 9 | 3 | 2011 | 0.16 | 0.59 | 0.76 |

# Appendix A. Modeling Methods

## Photochemical Grid Model and Source Apportionment

To quantify the ozone impacts due to precursor emissions from individual power plants and other source groups, STI performed CAMx OSAT source apportionment model simulations for the 2011 ozone season (May to September). The modeling domain and configurations used were based on those developed by EPA in recent ozone transport assessments using CAMx OSAT (U.S. Environmental Protection Agency, 2014a), and included the use of the carbon-bond 6 revision 2 gas phase chemistry mechanism.

The Comprehensive Air Quality Model with Extensions (CAMx version 6.1) (ENVIRON International Corporation, 2014) is a publically available, peer-reviewed, state-of-the-science three-dimensional grid-based (Eulerian) photochemical air quality model designed to simulate the emission, transport, diffusion, chemical transformation, and removal of gaseous and particle pollutants in the atmosphere over spatial scales ranging from continental to urban. CAMx was designed to approach air quality as a whole by including capabilities for modeling multiple air quality issues, including tropospheric ozone, fine particles, visibility degradation, acid deposition, air toxics, and mercury. The ability of photochemical grid models such as CAMx to treat a large number of sources and their chemical interactions makes them well suited for assessing the impacts of natural and anthropogenic emissions sources on air quality. CAMx is widely used to support regulatory air quality assessments and air quality management policy decisions in the United States. In recent years, the EPA has used CAMx to support the NAAQS designation process (U.S. Environmental Protection Agency, 2014a) and evaluate interstate pollutant transport (U.S. Environmental Protection Agency, 2005).

CAMx also includes Ozone Source Apportionment Technology (OSAT), which can be used to estimate the contributions of individual sources, groups of sources, or source regions to ozone concentrations at a given receptor location (Yarwood et al., 1996). Source apportionment modeling is useful for understanding model performance, designing emission control strategies, and performing culpability assessments to identify emission sources that contribute significantly to pollution (ENVIRON International Corporation, 2010). The key precursor species for ozone production are volatile organic compounds (VOC) and oxides of nitrogen ($NO_x$). OSAT uses reactive tracers to track the fate of these precursor emissions and the ozone formation resulting from them within a CAMx simulation. The ozone and precursors are tracked and apportioned by OSAT without perturbing the host model chemistry; therefore the OSAT results are fully consistent with the host model results for total concentrations. OSAT can efficiently estimate source contributions from multiple emission sources within a single model simulation. Importantly, while source apportionment modeling can be used to estimate source contributions to ozone concentrations for a given set of emission inputs, sensitivity modeling approaches such as brute-force modeling[5] or the direct decoupled method (DDM)[6] are

[5] The brute-force modeling method involves running the model both with and without emission controls applied to the source(s) of interest. The difference in pollutant concentrations between the two simulations yields the impact of the emission control scenario.

needed to quantify the effect of a given emission control scenario (e.g., 90% $NO_x$ reduction at power plants) on ozone concentrations.

In this work, the Anthropogenic Precursor Culpability Assessment (APCA) extension of OSAT was used. APCA is based on OSAT, but calculates source contributions a little differently to recognize the fact that biogenic (or non-anthropogenic) emissions are not controllable. For example, when ozone is formed by reactions between biogenic VOC and anthropogenic $NO_x$, APCA apportions the ozone contribution entirely to the anthropogenic source. APCA only apportions ozone contributions to biogenic sources when both the VOC and $NO_x$ precursors are from biogenic sources. APCA is useful for determining which source controls might have the greatest effect at reducing ozone concentrations.

## 2011 EPA Modeling Platform

The CAMx OSAT simulations were based on EPA's 2011 modeling platform. A modeling platform consists of a structured system of connected data and models that provide a consistent and transparent basis for assessing the air quality impact of anticipated changes in emissions. EPA develops and evaluates a new modeling platform each time the National Emissions Inventory (NEI) is updated (every three years). EPA has used the 2011 modeling platform to support development of revised ozone NAAQS (U.S. Environmental Protection Agency, 2014a) and to quantify future-year interstate contributions to ozone concentrations to help states address their obligations under the "Good Neighbor" provision of the Clean Air Act for the 2008 ozone NAAQS (U.S. Environmental Protection Agency, 2015).

The CAMx OSAT simulations relied on EPA's 2011v6.1 modeling platform, which was based on the 2011 NEI, Version 1 (2011NEIv1). The NEI is compiled by EPA on a triennial basis, primarily from data submitted by state, local, and tribal air agencies, and the 2011 NEI includes emissions from five source sectors: point sources, nonpoint (or area) sources, onroad mobile sources, nonroad mobile sources, and fire events.

For air quality modeling purposes, the 2011 NEI data was augmented by EPA to include biogenic emissions and data from Canadian and Mexican emissions inventories. In addition, the annualized point source data for electrical generating units (EGUs) in the 2011 NEI were replaced with hourly 2011 continuous emissions monitoring (CEMS) data for $SO_2$ and $NO_x$. Annual emissions for pollutants were converted to an hourly basis using CEMS input data (U.S. Environmental Protection Agency, 2011).

[6] DDM provides sensitivity coefficients that relate emissions changes to model outcomes. These sensitivity coefficients can be used to evaluate how pollutant concentrations would respond to a range of changes in emissions from a source or group of sources.

## Source Apportionment Tagging

After obtaining the 2011 modeling platform from EPA, STI worked withthe Sierra Club to identify sources and source groups to be tagged for ozone attribution analysis.Tagged sources fell into one of the following general categories:

- Individual coal-fired power plants (in some cases, specific coal-fired EGUs within a single facility were tagged separately);
- Groups of coal-fired power plants within a state or sub-state region (e.g., downstate New York);
- Groups of other (non-EGU) point sources within a state or sub-state region; and
- Non-point source sectors (e.g., biogenic sources and onroad mobile sources) within a state, sub-state, or multi-state region (e.g., states in the Southeast States Air Resources Managers [SESARM] consortium).

A total of 52 EGUs were individually tagged, while several dozen additional EGUs were tagged within 61 state and sub-state regions. Point sources that were tagged individually were not included in any of the state- or sub-state-level tag groups. In addition, each non-point source sector was tagged within 15 state, sub-state, or multi-state regions. Because of the large number of tags modeled, the processing was divided in to three separate CAMx OSAT simulations.White Bluff and Independence are represented by source tags I3 and I4 in Simulation 1. More detailed information on sources tagged in the CAMx OSAT simulations is provided in Appendix B.

## Meteorology

Meteorological inputs for the CAMx-OSAT simulations were developed by EPA for the 2011 modeling platform using version 3.4 of the Weather Research and Forecasting (WRF) numerical weather prediction model (Skamarock et al., 2008). The meteorological outputs from WRF include hourly varying winds, temperature, moisture, vertical diffusion rates, clouds, and rainfall rates. Additional details about this WRF simulation and its performance evaluation can be found in U.S. Environmental Protection Agency (2014b).

## Initial and Boundary Conditions

Initial and lateral boundary conditions were developed from three-dimensional global atmospheric chemistry simulations with GEOS-Chem standard version 8-03-02 with 8-02-01 chemistry (http://geos-chem.org) provided with the EPA 2011 platform. The GEOS-Chem predictions were translated into CAMx-ready initial and boundary conditions using code and procedures developed by Henderson et al. (2014), and modifications provided to STI by the Lake Michigan Air Directors Consortium (LADCO) to accommodate carbon-bond 6 chemistry species. OSAT tracks ozone transported through the boundaries, as well as ozone formation resulting from precursor emissions transported through the boundaries.

## Post-Processing

The raw result from a CAMx OSAT simulation is hourly ozone contributions from each source tag at each grid cell in the modeling domain for the 2011 ozone season. These hourly contributions were extracted and post-processed for several hundred receptor sites, listed in the electronic attachment provided with this memorandum. The receptors correspond to quality monitoring sites across the eastern half of the United States. At each receptor and for each day, the 8-hr average ozone contribution was calculated for all source tags using the averaging period corresponding to the period of highest modeled 8-hr average concentration at the receptor location. Although this analysis approach may not capture the largest ozone contributions modeled during the day, it does reflect contributions during time periods when ozone concentrations are highest. This analysis approach also ensures that ozone contributions from all source tags[7] sum to total modeled 8-hr ozone concentration each day.

## Model Performance Evaluation

EPA evaluated its 2011 modeling platform using statistical assessments of model predictions versus observations paired in time and space. Overall, the model performance statistics for ozone were within or close to the ranges found in other peer-reviewed applications (Simon et al., 2012) and were found to be suitable for use in a regulatory context (U.S. Environmental Protection Agency, 2014a).

[7] Including a leftover residual contribution from all untagged sources calculated by CAMx.

# Appendix B. OSAT Source Tags

Point source state groups (e.g., PA1, MDALL, and CTOTH) do not include point sources that were already tagged individually or point sources included in other state groupings from the same state.

## Simulation 1

| Tag Name | State | Tag Description |
|---|---|---|
| IC | N/A | Initial Conditions |
| BC | N/A | Boundary Conditions |
| biog | N/A | Biogenics |
| I2 | CT | Bridgeport Station |
| I5 | PA | Conemaugh |
| I6 | PA | Homer City Station |
| I7 | PA | PPL Brunner Island |
| I10 | PA | Bruce Mansfield |
| I11 | PA | Keystone |
| I12 | PA | PPL Montour |
| II7 | VA | Chesterfield |
| II9 | WV | Pleasants Power Station |
| I23 | IL | E D Edwards |
| I28 | WV | Harrison Power Station |
| I30 | WV | Fort Martin Power Station |
| I32 | WV | John E Amos |
| I33 | MI | St Clair |
| I34 | MI | Trenton Channel |
| I35 | IN | Clifty Creek |
| I36 | IL | Wood River |
| I37 | IL | Waukegan |
| I38 | OH | Kyger Creek |
| I39 | IL | Will County |
| I40 | OH | Cardinal |
| I41 | MI | J H Campbell |
| I43 | OH | General James M Gavin |
| I44 | OH | W H Sammis |
| I45 | IL | Powerton |
| I46 | MI | River Rouge |
| I49 | PA | Cheswick Power Plant |

| Tag Name | State | Tag Description |
|---|---|---|
| IL1 | IL | Illinois point group 1 |
| IL2 | IL | Illinois point group 2 |
| IN1 | IN | Indiana point group 1 |
| IN2 | IN | Indiana point group 2 |
| MD | MD | Maryland point group |
| MI | MI | Michigan point group |
| NJ1 | NJ | Illinois point group 1 |
| NJ2 | NJ | Illinois point group 2 |
| NY | NY | New York point group |
| OH1 | OH | Ohio point group 1 |
| OH2 | OH | Ohio point group 2 |
| PA1 | PA | Pennsylvania point group 1 |
| PA2 | PA | Pennsylvania point group 2 |
| VA1 | VA | Virginia point group 1 |
| VA2 | VA | Virginia point group 2 |
| WV | WV | West Virginia point group |
| NYEGU | NY | New York EGUs not individually tagged |
| NYUOTH | NY | Non-EGU point sources in upstate New York |
| NYDCMB | NY | New York "downstate" combustion sources |
| NYDOTH | NY | New York "downstate" point sources |
| PAEGU | PA | Pennsylvania EGUs not individually tagged |
| PAOTH | PA | Other Pennsylvania sources |
| NJCMB | NJ | New Jersey CMB sources |
| NJOTH | NJ | Other New Jersey point sources |
| CTCMB | CT | Connecticut combustion sources |
| CTOTH | CT | Other Connecticut point sources |
| MDALL | MD | Other Maryland point sources |
| VAALL | VA | Other Virginia point sources |
| OHALL | OH | Other Ohio point sources |
| INALL | IN | Other Indiana point sources |
| OTHER | N/A | CAMx "residual" contribution |
| total | N/A | Total ozone concentration |

## Simulation 2

| Tag Name | Tag Description |
|---|---|
| IC | Initial conditions |
| BC | Boundary conditions |
| biog_oth | Biogenic emissions from states not included in tagging |
| biog_CT | Connecticut biogenics |
| biog_DC | Washington D. C. biogenics |
| biog_IL | Illinois biogenics |
| biog_IN | Indiana biogenics |
| biog_MD | Maryland biogenics |
| biog_MI | Michigan biogenics |
| biog_NJ | New Jersey biogenics |
| biog_NYD | New York "downstate" biogenics |
| biog_NYU | New York "update" biogenics |
| biog_OH | Ohio biogenics |
| biog_PA | Pennsylvania biogenics |
| biog_SESARM | Biogenics from SESARM states |
| biog_VA | Virginia biogenics |
| biog_WV | West Virginia biogenics |
| biog_DE | Delaware biogenics |
| nonr_oth | Non-road emissions from states not included in tagging |
| nonr_CT | Connecticut non-road |
| nonr_DC | Washington D. C. non-road |
| nonr_IL | Illinois non-road |
| nonr_IN | Indiana non-road |
| nonr_MD | Maryland non-road |
| nonr_MI | Michigan non-road |
| nonr_NJ | New Jersey non-road |
| nonr_NYD | New York "downstate" non-road |
| nonr_NYU | New York "update" non-road |
| nonr_OH | Ohio non-road |
| nonr_PA | Pennsylvania non-road |
| nonr_SESARM | non-road from SESARM states |
| nonr_VA | Virginia non-road |
| nonr_WV | West Virginia non-road |
| nonr_DE | Delaware non-road |

| Tag Name | Tag Description |
|---|---|
| onr_oth | Onroad emissions from states not included in tagging |
| onr_CT | Connecticut onroad |
| onr_DC | Washington D. C. onroad |
| onr_IL | Illinois onroad |
| onr_IN | Indiana onroad |
| onr_MD | Maryland onroad |
| onr_MI | Michigan onroad |
| onr_NJ | New Jersey onroad |
| onr_NYD | New York "downstate" onroad |
| onr_NYU | New York "update" onroad |
| onr_OH | Ohio onroad |
| onr_PA | Pennsylvania onroad |
| onr_SESARM | onroad from SESARM states |
| onr_VA | Virginia onroad |
| onr_WV | West Virginia onroad |
| onr_DE | Delaware onroad |
| othr_oth | Other emissions (not addressed by the onroad, non-road, and biogenic tags) from states not included in tagging |
| othr_CT | Other emissions from Connecticut |
| othr_DC | Other emissions from Washington, DC |
| othr_IL | Other emissions from Illinois |
| othr_IN | Other emissions from Indiana |
| othr_MD | Other emissions from Maryland |
| othr_MI | Other emissions from Michigan |
| othr_NJ | Other emissions from New Jersey |
| othr_NYD | Other emissions from downstate New York |
| othr_NYU | Other emissions from upstate New York |
| othr_OH | Other emissions from Ohio |
| othr_PA | Other emissions from Pennsylvania |
| othr_SESARM | Other emissions from SESARM states |
| othr_VA | Other emissions from Virginia |
| othr_WV | Other emissions from West Virginia |
| othr_DE | Other emissions from Delaware |
| total_icbc | Total initial and boundary conditions |
| total_biog | Total biogenic emissions |
| total_nonr | Total nonroad emissions |

| Tag Name | Tag Description |
|---|---|
| total_onr | Total onroad emissions |
| total_othr | Total other emissions |
| total | Total ozone concentration |

## Simulation 3

| Tag Name | State | Plant Name |
|---|---|---|
| IC | N/A | Initial conditions |
| BC | N/A | Boundary conditions |
| biog | N/A | Biogenics |
| OTHER | N/A | CAMx "residual" contribution |
| total | N/A | Total ozone concentration |
| I1 | DE | Indian River Generating Station |
| I3 | AR | White Bluff |
| I4 | AR | Independence |
| I6 | TX | Big Brown |
| I8 | GA | Hammond |
| I9 | KS | Tecumseh Energy Center |
| I13 | TX | W A Parish |
| II4 | TX | Coleto Creek |
| II5 | TX | Monticello |
| II6 | TX | Fayette Power Project (a.k.a. Sam Seymour) |
| II8 | TX | Martin Lake |
| I20 | TX | Pirkey |
| I21 | TN | Kingston |
| I22 | KY | Kenneth C Coleman |
| I24 | TN | Gallatin |
| I25 | KY | Elmer Smith |
| I26 | KY | E W Brown |
| I27 | KY | Shawnee |
| I29 | MO | Thomas Hill |
| I31 | MO | Sioux |
| I42 | NC | G G Allen |
| I47 | GA | Scherer |
| I48 | NC | Marshall |
| I50 | OK | Muskogee |

| Tag Name | State | Plant Name |
|---|---|---|
| I51 | OK | GRDA |
| AL1 | AL | Alabama point group 1 |
| AL2 | AL | Alabama point group 2 |
| AR | AR | Arkansas point group |
| FL1 | FL | Florida point group 1 |
| FL2 | FL | Florida point group 2 |
| GA | GA | Georgia point group |
| IA1 | IA | Iowa point group 1 |
| IA2 | IA | Iowa point group 2 |
| KS | KS | Kansas point group |
| KY1 | KY | Kentucky point group 1 |
| KY2 | KY | Kentucky point group 2 |
| LA | LA | Louisiana point group |
| MA | MA | Massachusetts point group |
| MN1 | MN | Minnesota point group 1 |
| MN2 | MN | Minnesota point group 2 |
| MO | MO | Missouri point group |
| MS1 | MS | Mississippi point group 1 |
| MS2 | MS | Mississippi point group 2 |
| NC | NC | North Carolina group |
| NE1 | NE | Nebraska group |
| NH | NH | New Hampshire point group |
| OK1 | OK | Oklahoma point group 1 |
| OK2 | OK | Oklahoma point group 2 |
| SC1 | SC | South Carolina point group 1 |
| SC2 | SC | South Carolina point group 2 |
| TN1 | TN | Tennessee point group 1 |
| TN2 | TN | Tennessee point group 2 |
| TX1 | TX | Texas point group 1 |
| TX2 | TX | Texas point group 2 |
| WI1 | WI | Wisconsin point group 1 |
| WI2 | WI | Wisconsin point group 2 |

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